Washington State Department of Transportation

SoundTransit

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Federal Highway Administration
Federal Transit Administration

Final
Freeway Traffic Operations Report

Prepared for

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ACRONYMS

AADT	average annual daily traffic
BRT	bus rapid transit
CD	collector-distributor
CORSIM	corridor simulation
EIS	environmental impact statement
FHWA	Federal Highway Administration
GP	general purpose
HCT	High Capacity Transit
HOV	high-occupancy vehicle
SOV	single-occupancy vehicle
TDM	Transportation Demand Management
vph	vehicles per hour
WSDOT	Washington State Department of Transportation

1. INTRODUCTION

The purpose of this report is to define the traffic operational differences between the No-Action Alternative and three build alternatives as defined by the SR 520 Trans-Lake Washington Project team. Operational differences are discussed as they relate to the SR 520 corridor. Because the east/west SR 520 corridor provides a critical regional connection between the two major north/south freeway corridors, I-5 and I-405, a discussion of the traffic operational interrelationships of these two corridors is also provided.

The report is organized to provide information on the analysis results and what might be expected for traffic operations during the year 2030 based on land use forecasts and traffic distribution patterns. The report includes the following sections:

- This chapter, Chapter 1, discusses the purpose of and need for the proposed action and describes the alternatives analyzed.
- Chapter 2 describes the methodology used for the future alternatives analysis.
- Chapter 3 presents and discusses the findings of the freeway operations analysis. Graphics are used in this section to provide a complete understanding of SR 520 corridor operations. These graphics provide critical volume, speed, and congestion information for the entire corridor.
- Chapter 4 describes areas where future local street operations and freeway operations would impact one another. Again, graphics are used for this discussion to provide a visual representation of where operational constraints occur.
- Chapter 5 presents the conclusions of this analysis.
- Chapter 6 discusses future action plans.
- Appendices A through C provide the technical data used for completing this report.

1.1.1 Corridor Location and Service Area

The SR 520 corridor is an east-west corridor that connects Seattle and Redmond. The corridor extends across Lake Washington. The SR 520 corridor serves three highways of regional significance: SR 202, I-405, and I-5. SR 520 also serves many major urban centers, including Redmond, Bellevue, Kirkland, Seattle, and subareas of Seattle such as the University District and Capitol Hill. **Figure 1** depicts the project vicinity.

1.1.2 Project Origin

The Trans-Lake Washington Study Committee was appointed by the State of Washington's former Secretary of Transportation in May of 1998 to recommend a set of feasible solutions to improve mobility across and around the north end of Lake Washington. The 47-person Study Committee represented local governments and state and regional agencies, as well as neighborhood, business, and advocacy interests within the Trans-Lake corridor.

Insert Figure

1 Project Study Area

Over a 14-month period, the Trans-Lake Washington Study Committee developed a Problem Statement and created and evaluated alternative mobility concepts across a full range of transportation solutions. The Study Committee has recommended an array of Trans-Lake alternative solutions to be carried forward to a formal environmental impact study.

A multi-level screening process was used to screen out alternatives that were developed in early stages of the Trans-Lake Study. This process systematically utilized various measures of effectiveness to select a list of alternatives that would be carried forward to the environmental impact statement (EIS) process. **Figure 2** provides a visual representation of the process used to select the final alternatives. Supporting documents are available for each step in the process that support the decisions made.

The Trans-Lake Executive Committee has selected the project's Preliminary Preferred Alternative, which consists of the following elements:

- SR 520 High-Occupancy Vehicle (HOV)/Bus Rapid Transit (BRT) Lanes (Six-Lane Alternative)
- Light rail on I-90; separate process
- Accommodation of future High Capacity Transit (HCT) on SR 520

The Preliminary Preferred Alternative has the two additional elements that were not specifically defined in the Six-Lane Alternative definition; however, the light rail on I-90 would be assumed whether the Preliminary Preferred Alternative was the Six-Lane or Eight-Lane Alternative. The allowance for HCT on SR 520 does not affect the Six-Lane traffic forecasts and is provided to ensure the corridor is designed such that the eventuality of an HCT system could be served across the floating bridge.

1.2 PURPOSE AND NEED

1.2.1 Purpose of the Proposed Action

The purpose of the proposed action is to improve mobility for people and goods across Lake Washington within the SR 520 corridor from Seattle to Redmond in a manner that is safe, reliable, and cost-effective, while avoiding, minimizing, and/or mitigating impacts on affected neighborhoods and the environment.

1.2.2 Need for the Proposed Action

Adapted from the Trans-Lake Washington Study Committee Problem Statement, November 5, 1998

Land Uses and Transportation Systems Are Not Integrated in Their Planning and Implementation

The evolution of our transportation system has not kept pace with rapid job and residential growth. Neither transit development, demand management programs, roadway capacity additions, nor financing systems have been sufficient to keep pace with the trips generated by this growing population. Adopted local and regional growth management and transportation plans and policies are tending to concentrate and integrate residential employment patterns more than in the past, partly in an effort to ease burdens on the transportation system. However, substantial infrastructure investments, transit service, and demand management policies also called for by those plans have only been partially implemented. Infill has placed greater burdens on the existing system. Given this context, congestion levels in the SR 520 corridor are projected to get worse in the next 10 to 20 years.

Insert Figure

2 Alternatives Screening Process

The Transportation System Suffers From Extensive Congestion

Vehicle miles traveled have been growing as fast as or faster than the population. During much of the day, and especially at peak commute periods, highway lanes across and around the north end of Lake Washington and routes feeding those facilities are heavily congested. When congestion occurs on trans-lake routes, it backs up onto major north-south corridors and adjacent arterials, congesting those routes as well. Those users dependent on these routes for safe regional travel and the movement of freight and goods experience travel delays, lack of predictability, and a corresponding loss of economic productivity and overall quality of life.

Reliability and Safety of the System Are Impaired

The state highway, arterial, and local street systems around and adjacent to the lake are vulnerable to incident-caused backups. Minor incidents generate substantial delays throughout the entire system; major incidents cause near gridlock conditions as vehicles avoid a blocked route only to crowd others. Conflict between regional and local traffic, lack of adequate alternative modes, linkages to the rest of the system, weave patterns near interchanges, and substandard HOV lanes and/or the lack of shoulders also contribute to this unreliability and to a reduction in safety. A longer-term issue affecting system reliability and safety is the structural condition of the pontoon section of the Evergreen Point Floating Bridge. Where HOV lanes, metering, or preferential treatment are not present, transit and carpool users are delayed by traffic congestion in general-purpose (GP) lanes, reducing the effectiveness of existing transit and ridesharing services. For those desiring pedestrian or bicycle travel, the system is incomplete, making those options either impossible or unsafe.

Neighborhoods, Business Centers, and the Environment are Impacted

High traffic volumes negatively impact the livability of neighborhoods and the access to local arterials and smaller residential streets in the vicinity of cross-lake routes. A lack of adequate mitigation results in cut-through traffic, noise, vibration, air pollution, dust, and restricted access for local residents and local businesses. Walking and bicycling are made less safe and enjoyable. Considerable land is consumed and some neighborhoods are effectively divided. Vehicle emissions negatively impact air and water quality throughout the region.

1.2.3 Historic and Projected Future Growth

The Washington State Trends Analysis conducted by the Transportation Planning department of the Washington State Department of Transportation (WSDOT) identified several factors influencing future traffic growth and the need for infrastructure improvements to serve traffic demand. The state population is projected to increase by 36.5 percent by the year 2020, with 50 percent of the total population in King and Snohomish counties. The Trends Analysis did not project out to the year 2030; however, the interim year data provides a historic average weekday traffic volume growth along the SR 520 corridor at the bridge mid-span and is presented in **Figure 3**. Traffic volume growth over the past 10 years has averaged 0.5 percent per year along the SR 520 corridor. This level of growth is reasonable due to the constrained nature of the corridor within an established urban area. Because traffic demands meet or exceed available capacity during peak periods, most of this daily volume growth has occurred during mid-day and early morning hours (e.g., 9:00 AM to 3:00 PM, 7:00 PM to 6:00 AM), creating longer peak commute periods and extending the duration of congestion.

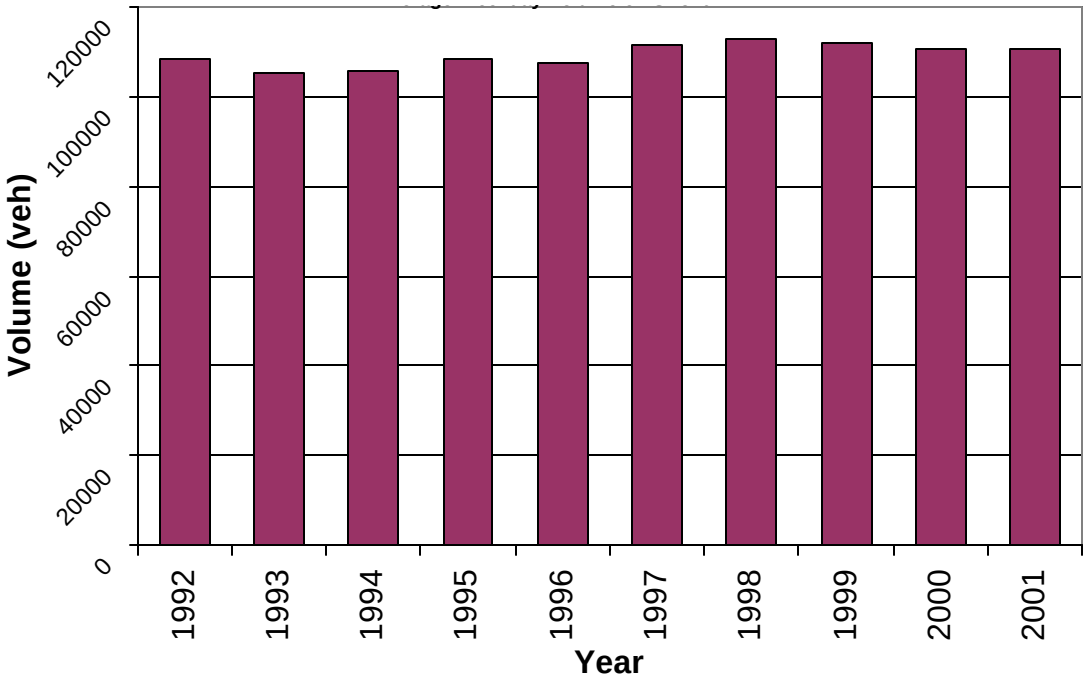

Figure 3
SR 520 Historical Data

The SR 520 Trans-Lake Washington Project travel demand forecasting model has estimated a 20 percent daily traffic volume growth between the years 2000 and 2030 for the No-Action Alternative for traffic crossing the SR 520 floating bridge. This equates to a compounded growth rate of 0.6 percent per year, very close to the historical data shown above. Growth in traffic volume is estimated to be greater to the east of the I-405 corridor. This is consistent with the higher traffic volumes that currently occur east of I-405 and the availability of developable land in that same area.

Traffic volumes along the SR 520 corridor are the highest just east of I-405, with an average annual daily traffic (AADT) volume of 129,000 vehicles. This is in comparison with the mid-span of the SR 520 floating bridge AADT of 102,000 vehicles. This indicates that there is a large demand for traffic between the I-405 corridor and SR 520 east of I-405.

1.2.4 Transportation System Performance

SR 520 provides one link in a series of freeways and highways connecting to the arterials of major urban centers in the Puget Sound region. Four major freeway facilities serve large volumes of traffic into the urban centers: I-5, I-405, SR 520, and I-90. The major arterials are those that have direct connections to the freeways. The two transportation systems must work together to serve traffic volume between each other in a relatively seamless manner.

The SR 520 corridor transportation system performance was measured by combining the freeway and local traffic demands and the various alternative geometrics in a traffic simulation tool that provides reasonable representation of how each system supports the other. For example, if there was severe congestion on the freeway system, then the traffic projected on the local arterial would not reach its destination in the scheduled time frame. This would cause traffic to spread further into the peak period, extending the congestion time at the congestion point.

Another important component of system performance is determining how the freeway system capacity constraints affect the amount of traffic that can reach various segments of the SR 520 corridor and the final destinations. These capacity constraints are initially identified using the CORSIM (corridor simulation) freeway operations model developed for the SR 520 corridor and portions of I-5 and I-405.

1.2.5 Regional Transportation Plans

The SR 520 corridor directly serves several urban centers, including downtown Redmond, Overlake, and the University of Washington. The corridor also serves downtown Seattle, downtown Bellevue, downtown Kirkland, and Totem Lake via connections with I-405 and I-5.

The current Washington State Transportation Plan identifies SR 520 for upgrades between the I-5 and SR 202 interchanges. The SR 520 corridor is also identified in Puget Sound Regional Council's Metropolitan Transportation Plan for widening from four to six lanes by the year 2030. Future traffic volume forecasts are based on information from Puget Sound Regional Council's regional travel demand forecasting model. This model contains year 2030 land use projections for the entire four-county region (King, Snohomish, Pierce, and Kitsap) based on the local comprehensive plans in each jurisdiction.

1.3 DEFINITION OF ALTERNATIVES

The final alternatives resulting from the SR 520 Trans-Lake Washington Project alternatives screening process are listed below with a brief definition. These definitions provide a description of the major modifications assumed to occur on the freeways and some of the major modifications to adjacent arterial systems. As part of the study process, further modifications to both systems are recommended and summarized at the end of this report.

1.3.1 Alternative 1: No-Action

The No-Action Alternative would not include construction of any new improvements on SR 520. It is assumed that SR 520 would be maintained and operated as it is today. It would not include replacement of the floating bridge or any of the bridge structures to reduce the risk of failure due to catastrophic events such as a major storm or an earthquake.

1.3.2 Alternative 2: Four Lanes – Safety and Preservation

Alternative 2 would replace the floating bridge because of its limited remaining service life and would replace seismically deficient bridges on SR 520 (including Portage Bay and any other fixed structures across Lake Washington). Alternative 2 would not include any major capacity improvements to SR 520.

SR 520 from I-5 on the west to 108th Avenue NE/Bellevue Way NE on the east, with a few exceptions, would be reconstructed to current design standards, including 4-foot-wide inside and 10-foot-wide outside shoulders. The facility would be realigned to the north at Portage Bay and across Lake Washington.

A 12-foot-wide bicycle and pedestrian path would be provided along SR 520 between Lake Washington Boulevard in Seattle and 96th Avenue NE in Kirkland, connecting with existing bicycle and pedestrian paths. Stormwater and drainage facilities would be constructed along the corridor from I-5 to Bellevue Way.

Alternative 2 would include the following interchange and over/undercrossing improvements:

- The I-5 Interchange would be modified to provide an HOV direct connection to the I-5 reversible lane for the west to south and north to east movements. No other improvements to I-5 are included with this alternative.

- The Montlake interchange would be reconstructed and would include a median transit flyer stop.

- The Lake Washington Boulevard interchange would be reconstructed, providing the same functional connections that exist today.

- Undercrossings at Evergreen Point Road, 84th Avenue NE, 92nd Avenue NE, and Bellevue Way NE would be replaced. The Evergreen Point flyer stop would be reconstructed on the outside of the roadway. The 92nd Avenue transit flyer stop would be eliminated.

A $300 million (year 1998 dollars) Transportation Demand Management (TDM) package would be included in this alternative. The TDM package would include a framework TDM and land use corridor agreement that would implement the SR 520 TDM Program and outline the expected actions and commitments of the parties involved. Oversight of the TDM Program would be guided by adaptive management principles, allowing flexibility to adjust the TDM strategies over time to support meeting the framework TDM and land use corridor agreement's goals. Major elements of the TDM program would include vanpooling programs; public information, education, and promotion programs; employer-based programs; land use as TDM; and other miscellaneous programs.

1.3.3 Alternative 3: Six Lanes – 4 GP and 2 HOV/Bus Rapid Transit (BRT) Lanes

For Alternative 3 on SR 520, a continuous HOV/BRT lane and two GP lanes would be provided each way from I-5 to Union Hill Road, for a minimum of six lanes, with the HOV/BRT lanes on the inside. The year 2030 HOV/BRT lane was analyzed as exclusive to 3+ occupancy vehicles and high-frequency transit. To improve performance and safety, the HOV/BRT lanes would be separated from the GP lanes by a 4-foot buffer.

The design would also include lanes that add to the freeway from one interchange on-ramp and drop to the next interchange off-ramp, also known as auxiliary lanes. Auxiliary lanes would be added between the following interchanges:

- I-5 and Montlake Boulevard

- 92nd Avenue NE and Bellevue Way NE

- Bellevue Way NE and I-405

- I-405 and 148th Avenue NE

- 148th Avenue NE and NE 40th Street

- West Lake Sammamish Parkway and Redmond Way/SR 202

Alternative 3 would include the following interchange and over/undercrossing improvements:

- The interchange at I-5 would be reconstructed with HOV ramps connecting to the reversible lanes both north and south of the interchange. It would also include an added auxiliary lane to southbound I-5 from SR 520 to Stewart Street.

- The interchanges at Montlake Boulevard, Lake Washington Boulevard, Bellevue Way NE, and I-405 would be completely reconstructed with all new bridges and ramps. Two options are included for crossing the Montlake Cut. One option would leave the existing Montlake Bridge unchanged and functioning as it does today. The second option would include braided HOV ramps and a second bascule drawbridge parallel to and east of the Montlake Bridge. When ramps are braided they change position with each other by having one cross over the other. Each bascule bridge would carry three lanes of traffic in one direction (two GP and one HOV).

- SR 520 interchanges at 84th Avenue NE, 92nd Avenue NE, 124th Avenue NE, 148th Avenue NE, and West Lake Sammamish Parkway would be upgraded to current design standards. The current configuration at these interchanges may have substandard acceleration/deceleration lane lengths or lane widths.

- The Redmond Way/SR 202 interchange would be reconstructed to provide a system ramp connection between westbound SR 202 and westbound SR 520 in addition to a second mainline bridge crossing over Redmond Way. High occupancy vehicle facilities would be constructed to include a direct connection to the Bear Creek Park & Ride along with a grade-separated crossing of Union Hill Road.

- High occupancy vehicle direct access ramps (to/from the west only) would be constructed at 108th Avenue NE, NE 31st Street, Avondale Road, and to a future site southeast of Union Hill Road.

- The Bellevue Way interchange reconstruction would close the existing ramps at 108th Avenue NE and combine them to form a new combined interchange at Bellevue Way NE. A median transit flyer stop would be constructed under Bellevue Way.

- At I-405, all of the existing system ramps would be demolished and replaced by new ramps that provide a higher design speed. In addition, HOV-to-HOV system ramps would be provided in three quadrants (NW, SW, and SE). The new interchange configuration would eliminate the existing weave sections between I-405 and 124th Avenue NE.

The Portage Bay Viaduct and fixed and floating bridge structures across Lake Washington would be replaced. The width assumes current design standards throughout the length of the corridor.

A 12-foot bicycle/pedestrian path would be provided on the north side of the new facility (with the exception of Evergreen Point to 92nd Avenue NE, where the path would be on the south side) and would provide a continuous, grade-separated corridor from Montlake to Redmond.

Several segments in the corridor would be lidded, and other segments would have noise walls; these designs are in progress and would become part of the project description for the EIS analysis.

Stormwater facilities would be constructed in the corridor.

A $264 million TDM package would be included in this alternative, similar to the one described under Alternative 2.

1.3.4 Alternative 4: Eight Lanes – 6 GP and 2 HOV/BRT Lanes

Alternative 4 is similar to Alternative 3, but would add a third GP lane in each direction between I-5 and SR 202/Redmond Way, for a total of eight lanes. One exception is within the Montlake and Lake Washington Blvd interchanges, where two GP lanes in each direction are continuous. The third general-purpose lane would be added and dropped on each side of the interchange. In addition, HOV/BRT lanes would be constructed from the West Lake Sammamish Parkway Interchange east over Union Hill Road to Avondale Road. East of the West Lake Sammamish Parkway interchange, Alternatives 3 and 4 are identical.

A four-lane cut-and-cover underground tunnel would be constructed at the Montlake Interchange from SR 520 at the MOHAI parking lot to the Pacific/Montlake Blvd intersection. This connection would be created to relieve the amount of traffic traveling across the Montlake Bridge and serve it directly into the primary intersection destination.

In addition, the NE 40th Street and NE 51st Street Interchanges would be partially reconstructed and the HOV direct access at NE 31st Street would be replaced by a median transit flyer stop at NE 40th Street.

A $234 million TDM package would be included in this alternative; similar to the one described under Alternative 2.

2. METHODOLOGY

2.1 INTRODUCTION

The objective of this freeway analysis is to assess existing and year 2030 operational characteristics. The alternatives as defined in the previous section were simulated with future year 2030 traffic data to evaluate operational effectiveness and identify potential design modifications. The focus of analysis was on the SR 520 freeway's mainline and HOV lanes and ramps, as well as impacts to the I-5 and I-405 freeway mainline and ramps. The limits of the study were as follows:

- SR 520: I-5 interchange to Avondale Road/SR 202
- I-5: NE 45th Street to the I-90 collector-distributor (CD)
- I-405: NE 70th Street to NE 8th Street/NE 4th Street.

The SR 520 corridor was simulated using the CORSIM micro-simulation package developed and supported by the Federal Highway Administration (FHWA). CORSIM includes detailed freeway, ramp, and HOV simulation output (animation and performance data), which were used to evaluate operational differences for the various alternatives.

Analysis required a three-step process that consisted of data collection, travel forecasting, and simulation. Each of these steps includes many substeps in order to develop an accurate assessment of each alternative. The three steps are defined in more detail in the following sections.

2.2 TIME PERIODS ANALYZED

Because congestion already occurs for over 2 hours in the morning and 2 hours in the evening, and because traffic volumes are expected to increase by 20 percent in the next 30 years, it was decided to simulate SR 520 corridor operations for the 4.5 peak hours.

The peak-period travel demands were segmented into 15-minute time periods over a 5-hour peak period for both the AM and PM peaks. The peak periods analyzed were from 5:00 to 10:00 AM and 2:30 to 7:30 PM. The purpose of analyzing the 5-hour peak period encompassing the peak hour was to capture the peak spreading that occurs as demand exceeds capacity during a portion of this peak period.

2.3 DATA COLLECTION

WSDOT's Traffic Systems Management Center collected 24-hour traffic counts for all ramp locations, mainline screenlines, and existing queue locations for the years 1999 through 2001. Traffic volumes were verified with year 2000 Ramps and Roadways peak-hour volumes to provide the final base year 2000 traffic volume data.

In an effort to capture the dynamic nature of traffic along an urban corridor, data was collected at each of the ramps at 15-minute intervals. This level of data collection preserved the various peaking characteristics of each ramp location so that the future operations would reflect similar operational dynamics.

The locations and duration of existing vehicle queues were identified at several locations. Existing traffic count volumes were adjusted based on field observations. Adjustments were made to represent the traffic demand versus the throughput recorded in the traffic count data for the 15-minute time intervals. Examples of where this might occur include a metered on-ramp with significant queuing or a particular bottleneck on the freeway, such as a bridge, that effectively meters the traffic flow.

2.4 TRAVEL FORECASTING

Travel demand forecasting was completed using the Puget Sound Regional Council's EMME/2 transportation planning model as a base. Modifications were made to the regional model as defined in the *Travel Forecasting Model Validation Report for Base Year 1998* to ensure that the model portrayed accurate data for the project. The validation effort confirmed that daily traffic volumes were similar between existing data and the base year model output.

The alternatives were then modeled using the 1998 base EMME/2 model, and the traffic volume growth was projected to the year 2030 for each of the alternatives. The model output data is typically most reliable at a freeway screenline level along the corridor, but not at an intersection level; therefore, the SR 520 project team used the screenline level growth factors to develop future traffic volume estimates. This process involved a balancing process through each of the interchanges that would incorporate local traffic growth and freeway on- and off-ramp growth in traffic volumes. This process is more clearly defined in the Year *2030 Travel Forecasting Working Paper*. Results of the travel forecasting effort are also included in the working paper.

2.5 SIMULATION

The first step to the simulation process was to verify that the simulation model correctly represented existing freeway operations. Calibration of the CORSIM model was accomplished such that AM and PM peak period model output closely matched existing mainline and ramp volumes. Calibration was completed assuming a reasonable +/-10 percent volume error, with most locations at less than +/-5 percent error. Queue and speed data output from the model were also verified to reasonably match field observations and WSDOT archived operations data. This calibration effort utilized ramp lengths, acceleration and deceleration lengths, and car following sensitivity as variables. The ramp, acceleration, and deceleration lengths were set to closely match existing conditions, with some modifications to achieve the proper vehicle responses at the merge points.

After the simulation process was complete, the alternatives were coded into the simulation model. The ramp, acceleration, and deceleration lengths were lengthened by the relative difference between the existing and future design lengths as shown in the plan sheets. This provided for a similar driver behavior, but expected improved traffic operations due to improvements in design.

The last step of the simulation process was summarizing the simulation output data and providing recommendations for design modifications for further study. Each of the alternatives was summarized using four basic measures of effectiveness. The measures used for comparison were demand volume, served volume, and unserved volume; speed; travel time; and vehicular queuing.

Three of the measure's results are presented in pull-out figures, while the volume data are provided on a separate figure for each direction of travel during each peak period for each alternative. Summary data are provided for each of the 15-minute intervals simulated to provide a clear picture of the level of operations.

2.6 MEASURES OF EFFECTIVENESS

The following measures of effectiveness were used to evaluate and compare traffic operations among the alternatives. The measures of effectiveness were initially developed and approved by the Trans-Lake Advisory, Technical, and Steering Committees for the first- and second-level screening processes shown previously on **Figure 2**.

2.6.1 Traffic Volumes

Traffic analysis for a freeway facility that is currently operating at or over capacity during the peak hour or throughout the peak period creates a challenge for estimating future traffic volumes. Because over-capacity conditions already occur along the SR 520, I-5, and I-405 corridors, a traffic volume forecasting and analysis methodology that accounts for the over-capacity conditions throughout multiple hours was selected.

There are two types of traffic volumes discussed throughout this report: traffic demand and traffic served. Traffic demand refers to the number of vehicles during a given time period that are present on the freeway, whether they are moving or stopped. Traffic served refers to the number of vehicles that are moving beyond a point of reference during a given time period. For uncongested locations, traffic demand equals traffic served. For congested locations, traffic demand is always higher than the traffic served due to over-capacity conditions. The traffic demand that is not served due to these over-capacity conditions queues up but is eventually served through later time periods.

Traffic volume forecasting methodology began by collecting existing traffic data with an accounting method that summed the total trips onto the SR 520 corridor at each of the ramps under unconstrained (free-flow) conditions. This allowed the traffic volumes at the various bottleneck locations to exceed the maximum capacity condition, thus creating the existing vehicle queues on SR 520. Traffic demand is the input to the CORSIM model and traffic served is the output of the CORSIM model.

The Puget Sound Regional Council's regional travel demand forecasting model was then updated with the SR 520 corridor alternatives to determine what levels of traffic growth could be expected for the year 2030. The resulting growth rates were applied to existing traffic volume counts to develop the future year traffic volume estimates for each SR 520 alternative.

Because the existing freeway network is operating over capacity and the future freeway networks are expected to operate over capacity, the CORSIM model was used to determine how each of the alternatives would function given the future traffic demand estimates. The CORSIM model allowed the freeway networks on SR 520, I-5, and I-405 to be modeled in unison to determine how one freeway might affect an adjacent one. For example, a bottleneck (over-capacity segment) on I-5 or I-405 just north or south of SR 520 would prevent the total traffic demand from reaching SR 520. Therefore, traffic volumes that are ultimately served between the freeway systems are the CORSIM model output and represent the volume served.

2.6.2 Speed

Vehicle travel speeds are a measure of congestion and driver comfort. Freeway traffic operating at speeds exceeding 60 miles per hour (mph) is considered to be free-flow condition. Traffic operating at speeds between 30 and 55 mph indicates moderate congestion and below 30 mph indicates a highly congested condition. The existing speed limit on portions of the SR 520 corridor is 50 mph; however, the 60 mph threshold, indicating free-flow conditions, was used since a new or standardized facility would be

designed to accommodate higher travel speeds. Traffic operations along the freeways are summarized in 10-mph intervals between 0 and 50+ mph.

Speed data is a direct output from the CORSIM model. Data is provided in 15-minute intervals at each location along the SR 520 corridor. Speeds during each of the 15-minute intervals are plotted at the various locations along the corridor to provide a three-dimensional perspective of corridor operations. The three dimensions included in the charts are time, space, and speed. Instructions for reading the charts are provided in Section 3 – Freeway Operations Analysis.

The following example illustrates the effect speed has on travel time. The SR 520 corridor is approximately 13 miles in length and the free-flow speed on the corridor is about 60 mph. Traveling the 13 miles would take 13 minutes. But if the speed for the trip was 30 mph, the trip would require 26 minutes. The same comparison holds for comparing GP lanes and HOV lanes. If the GP lane operates at 30 mph and the HOV lane operates at 60 mph, then the HOV travel time would be cut in half.

2.6.3 Travel Time

The travel time for the various alternatives and freeway corridors was calculated to serve as a measure of the delay that drivers would experience on the corridor. Travel time is directly related to the corridor speed and has been calculated using the corridor speed data described in the previous section.

2.6.4 Vehicle Queues

The results from the vehicle queuing analysis reflect the impact of a corridor's limited capacity. Queuing is defined as a section that operates at speeds less than 30 mph. A queue may occur at on- or off-ramps due to weaving activity or a change in the number of lanes, lane width, grade, or other physical characteristics. A queue is measured by its duration and its length (distance upstream impacted). It should be noted that queues may develop even when vehicles are traveling at slow speeds along a freeway, i.e., under 30 mph.

3. FREEWAY OPERATIONS ANALYSIS

Three freeway corridors—SR 520, I-405, and I-5—were analyzed to determine the effectiveness of the SR 520 Trans-Lake Washington project alternatives. Both I-5 and I-405 provide north/south service between Lynnwood and Tukwila with I-5 serving the Seattle central business district and I-405 serving the Bellevue central business district. SR 520 is one of two critical links between the major employment centers east and west of Lake Washington. The other critical link is I-90; however, no modification to I-90 have been proposed as part of the Trans-Lake Washington project, therefore no analysis was completed for that corridor.

Simulation of existing and future conditions on the three corridors was completed at a very detailed level using a microscopic simulation model. A microscopic simulation model provides the most detailed simulation of a corridor operation for every segment of roadway simulated. Because every ramp junction and freeway segment between ramps was included in the simulation, the output data is very detailed and extensive. Summary of this level of detail has been prepared to describe the corridor operations and system interdependency for each alternative configuration of SR 520.

The transportation analysis was provided as a system-level summary. Simulation results are presented on a system-wide basis to show how traffic operations along the entire corridor change over time. This level of summary provides key information about the interconnectivity of the three freeway systems and the arterials. Charts have been prepared that illustrate the average vehicle speed for each 15-minute interval at all locations along the SR 520 corridor as output from the CORSIM model. The speeds have been summarized in 10-mph intervals from 0 to 50+ mph. Slow speeds are represented by darker colors and the free-flow speed has no color. Notes on the example congestion diagram in **Figure 4** describe how to interpret the congestion charts and how to determine corridor operations during any given time interval.

The following sections highlight key findings for each of the corridors simulated as part of this simulation effort. The first section provides detailed information that describes the operations of SR 520 and presents the system summary charts. The following sections describe key findings for the I-5 and I-405 corridors without the same presentation of the system charts. System charts are provided for I-5, I-5 express lanes, and I-405 in **Appendices A**, **B**, and **C**.

3.1 SR 520

A more detailed description of the SR 520 operations is provided in the following sections. Discussions of the freeway operations analysis results are accompanied by system summary charts in **Figures 5** through **14**.

Insert Figure

4 Speed and Location Example Chart

3.1.1 Existing Conditions AM Peak Period

Figure 5 shows the AM peak-period existing conditions (year 2000) on SR 520.

3.1.1.1 Westbound SR 520 Findings

In 2000, the following vehicle volumes are served across westbound SR 520 during the 4.5-hour AM peak period (between 5:30 and 10:00 AM): 15,400 at 124th Avenue NE; 16,400 at Mid-Span; and 15,400 at Montlake Boulevard. During this 4.5-hour period, the travel demands are met at each location.

Capacity constraints (i.e., bottlenecks) exist along SR 520 at the following locations:

- At the HOV termination point at Evergreen Point, congestion occurs for 2 hours during the morning peak, with traffic backed up to the Bellevue Way interchange area. Average travel speeds are below 30 mph during this time.

Capacity constraints on SR 520 mainline and ramps result in impacts to local streets and freeway system connections at the following locations:

- Queuing begins at the ramp meters on the Bellevue Way, 108th Avenue NE, and 84th Avenue NE on-ramps and extends onto the local system.

- Westbound SR 520 queues do not have a direct impact on the adjoining freeways.

The average westbound vehicle travel time on SR 520 from Avondale Road/SR 202 to I-5 during the 4.5-hour AM peak period is estimated as 19 minutes, or an average speed of 43 mph. The maximum westbound travel time on SR 520 from Avondale Road/SR 202 to I-5 is 24 minutes, resulting in an average travel speed of 33 mph.

3.1.1.2 Eastbound SR 520 Findings

In 2000, the following vehicle volumes are served across eastbound SR 520 during the 4.5-hour AM peak period (between 5:30 and 10:00 AM): 14,500 at 124th Avenue NE; 16,200 at Mid-Span; and 13,400 at Montlake Boulevard. During this 4.5-hour period, the following vehicle volumes are not served: 200 at 124th Avenue NE and 700 at Mid-Span; the demand is met at Montlake Boulevard.

Capacity constraints (i.e., bottlenecks) exist along SR 520 at the following locations:

- Montlake Boulevard on-ramp area shows stop-and-go congestion for over 1.5 hours of the AM peak period.

- Lake Washington Boulevard on-ramp area operates at 30 mph during the peak 2 hours, and vehicle queues extend back to the Montlake Boulevard interchange.

- Congestion occurs through the peak period between the I-405 southbound on-ramp and the 124th Avenue NE off-ramp due to the weave movement occurring in a short distance.

Insert Figure

5 2000 AM Peak Period Traffic Operations – Existing Conditions

Capacity constraints on SR 520 mainline and ramps result in impacts to local streets and freeway system connections at the following locations:

- The Lake Washington Boulevard eastbound on-ramp backs up onto the local arterials due to the ramp meter and freeway congestion.
- The eastbound queue from the Lake Washington Boulevard and Montlake on-ramps extends back to the I-5 on-ramps, resulting in occasional congestion onto the I-5 corridor.
- Traffic congestion on SR 520 between I-405 and 124th Avenue NE causes vehicles to queue on the ramps from I-405.

The average eastbound vehicle travel time on SR 520 from I-5 to Avondale Road/SR 202 during the 4.5-hour AM peak period is estimated to be 26 minutes, or an average speed of 30 mph. The maximum eastbound travel time on SR 520 from I-5 to Avondale Road/SR 202 is 29 minutes, resulting in an average travel speed of 27 mph.

3.1.2 Existing Conditions PM Peak Period

Figure 6 shows the PM peak-period existing conditions (year 2000) on SR 520.

3.1.2.1 Westbound SR 520 Findings

In 2000, the following vehicle volumes are served across westbound SR 520 during the 4.5-hour PM peak period (between 3:00 and 7:30 PM): 15,400 at 124th Avenue NE; 16,400 at Mid-Span; and 15,400 at Montlake Boulevard. During this 4.5-hour period, the travel demand is served.

Capacity constraints (i.e., bottlenecks) exist along SR 520 at the following locations:

- At the HOV lane termination point, congestion occurs for 3.5 of the 4.5 peak hours, with speeds below 30 mph. The queue extends from the east end of the floating bridge to I-405, with some locations operating at stop-and-go speeds for over 2 hours.
- Some congestion occurs near the Montlake westbound on-ramp, with traffic speeds near 30 mph for 1.5 hours.

The average westbound vehicle travel time on SR 520 from Avondale Road/SR 202 to I-5 during the 4.5-hour PM peak period is estimated as 26 minutes, or an average speed of 30 mph. The maximum westbound travel time on SR 520 from Avondale Road/SR 202 to I-5 is 29 minutes, resulting in an average travel speed of 27 mph.

3.1.2.2 Eastbound SR 520 Findings

In 2000, the following vehicle volumes are served across eastbound SR 520 during the 4.5-hour PM peak period (between 3:00 and 7:30 PM): 15,200 at 124th Avenue NE; 15,500 at Mid-Span; and 14,100 at Montlake Boulevard. During this 4.5-hour period the travel demand is served.

Insert Figure

6 2000 PM Peak Period Traffic Operations – Existing Conditions

Capacity constraints (i.e., bottlenecks) exist along SR 520 at the following locations:

- Lake Washington Boulevard on-ramp area shows traffic speeds in the range of 10 to 30 mph, with congestion occurring for over 1.5 hours of the PM peak period.

- Congestion begins at the east termini of the corridor due to local arterial congestion. The queuing extends back to the 40th/51st Street CD on-ramp, lasting for over 3 hours during the PM peak period.

Capacity constraints on SR 520 mainline and ramps result in impacts to local streets and freeway system connections at the following locations:

- Traffic queues onto SR 520 from the intersection of Union Hill Road and Avondale Road, creating much of the congestion on the SR 520 corridor.

The average eastbound vehicle travel time on SR 520 from I-5 to Avondale during the 4.5-hour PM peak period is estimated to be 22 minutes, or an average speed of 36 mph. The maximum eastbound travel time on SR 520 from I-5 to Avondale Road/SR 202 is 36 minutes, resulting in an average travel speed of 22 mph.

3.1.3 No-Action Alternative AM Peak Period

Figure 7 shows the year 2030 AM peak-period conditions on SR 520 that would result under the No-Action Alternative.

3.1.3.1 Westbound SR 520 Findings

In 2030, the following vehicle volumes would be served across westbound SR 520 during the 4.5-hour AM peak period (between 5:30 and 10:00 AM): 21,400 at 124th Avenue NE; 15,200 at Mid-Span; and 14,900 at Montlake Boulevard. During this 4.5-hour period, the following vehicle volumes would not be served: 600 at 124th Avenue NE; 2,000 at Mid-Span; and 1,400 at Montlake Boulevard.

Capacity constraints (i.e., bottlenecks) would occur on SR 520 at the following locations:

- Queuing would begin at the entry point freeway where Avondale Road and SR 202 on-ramps merge, with congestion lasting over 3.5 hours.

- Congestion would occur at the 148th Avenue on-ramp for about 1.5 hours, with speeds between 10 and 20 mph. This congestion would extend back to the 40th/51st CD on-ramp.

- Congestion would occur between the 124th Avenue NE on-ramp and the I-405 off-ramps due to the weaving traffic. Queuing would occur for nearly 2 hours with speeds between 40 and 50 mph and would extend for an hour to the 148th Avenue NE interchange.

Insert Figure

7 2030 AM Peak Period Traffic Operations – No-Action Alternative

Capacity constraints on SR 520 mainline and ramps would result in impacts to local streets and freeway system connections at the following locations:

- The Avondale Road/SR 202 queue would limit the amount of traffic that could utilize the corridor. Without this bottleneck, additional downstream congestion would occur.

The average westbound vehicle travel time on SR 520 from Avondale Road/SR 202 to I-5 during the 4.5-hour AM peak period is estimated to be 19 minutes, or an average speed of 43 mph. The maximum westbound travel time on SR 520 from Avondale Road to I-5 would be 22 minutes, resulting in an average travel speed of 36 mph.

I-405 capacity constraints would limit the amount of traffic reaching SR-520 by nearly 950 vehicles per hour (vph) during the peak period.

3.1.3.2 Eastbound SR 520 Findings

In 2030, the following vehicle volumes would be served across eastbound SR 520 during the 4.5-hour AM peak period (between 5:30 and 10:00 AM): 16,400 at 124th Avenue NE; 16,700 at Mid-Span; and 13,500 at Montlake Boulevard. During this 4.5-hour period, the following vehicle volumes would not be served: 7,000 at 124th Avenue NE; 5,000 at Mid-Span; and 3,600 at Montlake Boulevard.

Capacity constraints (i.e., bottlenecks) would occur on SR 520 at the following locations:

- Montlake Boulevard on-ramp area would have stop-and-go congestion for over 4 hours of the AM peak period.

Capacity constraints on SR 520 mainline and ramps would result in impacts to local streets and freeway system connections at the following locations:

- The Montlake/Lake Washington Boulevard queue would extend back to the I-5 corridor, resulting in congestion on I-5 for nearly 1.5 hours.

- Queuing would begin at the ramp meters on the Montlake Boulevard and Lake Washington Boulevard on-ramps and would extend onto the local arterials.

The average eastbound vehicle travel time on SR 520 from I-5 to Avondale Road/SR 202 during the 4.5-hour AM peak period is estimated to be 26 minutes, or an average speed of 31 mph. Travel times and speeds between I-5 and I-405 would be slower than east of I-405, with averages of 19 minutes and 22 mph, respectively. The maximum eastbound travel time on SR 520 from I-5 to Avondale Road/SR 202 would be 33 minutes, resulting in an average travel speed of 24 mph.

I-5 capacity constraints would limit the amount of traffic reaching SR 520 by over 750 vph during the peak period. I-405 capacity constraints would limit the amount of traffic reaching SR 520 by nearly 2,170 vph during the peak period. In particular, the single-lane northbound I-405 off-ramp to eastbound SR 520 would be over capacity. Approximately 30 percent of the traffic destined to eastbound SR 520 via this connection would not be served through the AM peak period.

3.1.4 No-Action Alternative PM Peak Period

Figure 8 shows the PM peak-period conditions on SR 520 that would result under the No-Action Alternative.

3.1.4.1 Westbound SR 520 Findings

In 2030, the following vehicle volumes would be served across westbound SR 520 during the 4.5-hour PM peak period (between 3:00 and 7:30 PM): 13,300 at 124th Avenue NE; 18,500 at Mid-Span; and 14,700 at Montlake Boulevard. During this 4.5-hour period, the following vehicle volumes would not be served: 11,200 at 124th Avenue NE; 4,100 at Mid-Span; and 2,700 at Montlake Boulevard.

Capacity constraints (i.e., bottlenecks) would occur on SR 520 at the following locations:

- Queuing would occur on the freeway mainline as the 148th Avenue NE on-ramp merges, with a duration of over 4.5 hours. The congestion would combine with queuing that would occur near the bridge and would extend to Avondale Road/SR 202.

- The off-ramps to I-405 would operate over capacity, resulting in a peak-hour stop-and-go condition that would extend back to the 148th Avenue NE congestion.

- At Bellevue Way, enough traffic would enter the over-capacity freeway within a short distance with traffic weaving over the HOV lane to create severe congestion.

- The 84th Avenue NE on-ramp congestion would occur due to on-ramp merging traffic, the termination of an outside HOV lane, and the merging transit traffic into the mainline. SR 520 speeds would drop below 30 mph during the full 4.5-hour peak period.

- Traffic congestion would occur at Montlake due to the short flyer stop deceleration and Montlake on-ramp acceleration lane lengths.

Capacity constraints on SR 520 mainline and ramps would result in impacts to local streets and freeway system connections at the following locations:

- The westbound NE 40th Street/NE 50th Street CD would operate over capacity, causing congestion to back onto the NE 50th Street arterial system.

- Freeway queuing would back up to the arterial system at the SR 202, West Lake Sammamish Parkway, NE 40th Street, NE 50th Street, and 148th Avenue NE interchanges.

- Queuing would begin at the ramp meter on the southbound Bellevue Way on-ramp and would extend into the local arterial system.

The average westbound vehicle travel time on SR 520 from Avondale Road/SR 202 to I-5 during the 4.5-hour PM peak period is estimated to be 110 minutes, or an average speed of 7 mph. Travel times and speeds would be relatively slow between I-405 and I-5, averaging 36 minutes and 12 mph, respectively. The maximum westbound travel time on SR-520 from Avondale Road/SR 202 to I-5 would be 153 minutes, resulting in an average travel speed of 5 mph.

Insert Figure

8 2030 PM Peak Period Traffic Operations – No-Action Alternative

I-405 capacity constraints would limit the amount of traffic reaching SR 520 by nearly 210 vph during the peak period.

3.1.4.2 Eastbound SR 520 Findings

In 2030, the following vehicle volumes would be served across eastbound SR 520 during the 4.5-hour PM peak period (between 3:00 and 7:30 PM): 16,600 at 124th Avenue NE; 16,200 at Mid-Span; and 13,700 at Montlake Boulevard. During this 4.5-hour period, the following vehicle volumes would not be served: 3,800 at 124th Avenue NE; 500 at Mid-Span; and 900 at Montlake Boulevard.

Capacity constraints (i.e., bottlenecks) would occur on SR 520 at the following locations:

- Lake Washington Boulevard queues would extend back to the Montlake Boulevard interchange area, with speeds below 30 mph during the peak 3-hour period.
- 92nd Avenue NE congestion would operate at speeds as low as 40 mph through the peak period.
- The eastern corridor terminus at the Union Hill intersection and Redmond Way would operate at stop-and-go conditions for the majority of the peak period.

Capacity constraints on SR 520 mainline and ramps would result in impacts to local streets and freeway system connections at the following locations:

- Congestion would occur approaching the ramp meter at the Montlake Boulevard on-ramp, likely extending back to the arterial system.
- Congestion beginning at the west terminus would spill back across SR 520 onto the local systems at the NE 51st Street, NE 40th Street, and 148th Avenue NE interchanges and onto the I-405 interchange ramps.

The average eastbound vehicle travel time on SR 520 from I-5 to Avondale Road/SR 202 during the 4.5-hour PM peak period is estimated to be 45 minutes, or an average speed of 17 mph. Travel times and speeds would be relatively slow between I-5 and I-405, averaging 34 minutes and 11 mph, respectively. The maximum eastbound travel time on SR 520 from I-5 to Avondale Road/SR 202 would be 86 minutes, resulting in an average travel speed of 5 mph.

I-5 capacity constraints would limit the amount of traffic reaching SR 520 by nearly 225 vph during the peak period. I-405 capacity constraints would limit the amount of traffic reaching SR 520 by nearly 760 vph during the peak period.

3.1.5 Safety and Preservation Alternative AM Peak Period

Figure 9 shows the AM peak-period conditions on SR 520 that would result under the Safety and Preservation Alternative.

3.1.5.1 Westbound SR 520 Findings

In 2030, the following vehicle volumes would be served across westbound SR 520 during the 4.5-hour AM peak period (between 5:30 and 10:00 AM): 21,100 at 124th Avenue NE; 14,900 at Mid-Span; and 14,800 at Montlake Boulevard. During this 4.5-hour period, the following vehicle volumes would not be served: 900 at 124th Avenue NE; 2,300 at Mid-Span; and 1,500 at Montlake Boulevard.

Capacity constraints (i.e., bottlenecks) would occur on SR 520 at the following locations:

- Queuing would begin at the entry point freeway where Avondale Road and SR 202 on-ramps merge, with congestion lasting over 3.5 hours.
- Congestion would occur at the 148th Avenue on-ramp for about 1.5 hours, with speeds between 10 and 20 mph. This congestion would extend back to the 40th/51st CD on-ramp.
- Congestion would occur between the 124th Avenue NE on-ramp and the I-405 off-ramps due to the weaving traffic. Queuing would occur for nearly 2 hours with speeds between 40 and 50 mph and would extend for an hour to the 148th Avenue NE interchange.

Capacity constraints on SR 520 mainline and ramps would result in impacts to local streets and freeway system connections at the following locations:

- The Avondale Road/SR 202 queue would limit the amount of traffic that could utilize the corridor. Without this bottleneck, additional downstream congestion would occur.

The average westbound vehicle travel time on SR 520 from Avondale Road/SR 202 to I-5 during the 4.5-hour AM peak period is estimated to be 18 minutes, or an average speed of 44 mph. The maximum westbound travel time on SR 520 from Avondale Road/SR 202 to I-5 would be 22 minutes, resulting in an average travel speed of 36 mph.

I-405 capacity constraints would limit the amount of traffic reaching SR 520 by nearly 975 vph during the peak period.

3.1.5.2 Eastbound SR 520 Findings

In 2030, the following vehicle volumes would be served across eastbound SR 520 during the 4.5-hour AM peak period (between 5:30 and 10:00 AM): 17,000 at 124th Avenue NE; 19,800 at Mid-Span; and 15,200 at Montlake Boulevard. During this 4.5-hour period, the following traffic volumes would not be served: 12,000 at 124th Avenue NE; 1,900 at Mid-Span; and 1,900 at Montlake Boulevard.

Capacity constraints (i.e., bottlenecks) would occur along SR 520 at the following locations:

- Congestion would occur where the two northbound I-5 on-ramps merge to a single lane onto SR 520.
- Montlake Boulevard on-ramp area would have stop-and-go congestion for over 3 hours of the AM peak period.

Insert Figure

9 2030 AM Peak Period Traffic Operations – Safety and Preservation Alternative

- Congestion would occur at the 92nd Avenue NE on-ramp for about 2 hours, with speeds below 30 mph. This congestion would extend back to 84th Avenue NE.

Capacity constraints on SR 520 mainline and ramps would result in impacts to local streets and freeway system connections at the following locations:

- Congestion at the I-5 on-ramps on SR 520 would extend back onto I-5 for nearly 3 hours during the AM peak period.

- Queueing would begin at the ramp meter on the Lake Washington Boulevard on-ramp and would extend onto the local arterials.

The average eastbound vehicle travel time on SR 520 from I-5 to Avondale Road/SR 202 during the 4.5-hour AM peak period is estimated to be 23 minutes, or an average speed of 34 mph. Travel times and speeds between I-5 and I-405 are relatively slow, averaging 17 minutes and 25 mph, respectively. The maximum eastbound travel time on SR 520 from I-5 to Avondale Road/SR 202 would be 27 minutes, resulting in an average travel speed of 29 mph.

I-5 capacity constraints would limit the amount of traffic reaching SR 520 by nearly 430 vph during the peak period. I-405 capacity constraints limit the amount of traffic reaching SR 520 by nearly 2,200 vph during the peak period.

3.1.6 Safety and Preservation Alternative PM Peak Period

Figure 10 shows the PM peak-period conditions on SR 520 that would result under the Safety and Preservation Alternative.

3.1.6.1 Westbound SR 520 Findings

In 2030, the following vehicle volumes would be served across westbound SR 520 during the 4.5-hour PM peak period (between 3:00 and 7:30 PM): 16,300 at 124th Avenue NE; 20,200 at Mid-Span; and 15,600 at Montlake Boulevard. During this 4.5-hour period, the following traffic volumes would not be served: 8,200 at 124th Avenue NE; 2,400 at Mid-Span; and 1,800 at Montlake Boulevard.

Capacity constraints (i.e., bottlenecks) would occur on SR 520 at the following locations:

- Queuing would occur on the freeway mainline as the 148th Avenue NE on-ramp merges, with a duration of over 4.5 hours. The congestion would combine with queuing that would occur near the bridge and would extend to Avondale Road/SR 202.

- The off-ramps to I-405 would operate over capacity, resulting in a peak-hour stop-and-go condition that would extend back to the 148th Avenue NE congestion.

- At Bellevue Way, enough traffic would enter the over-capacity freeway within a short distance with traffic weaving over the HOV lane to create severe congestion.

- The 84th Avenue NE on-ramp congestion would occur due to on-ramp merging traffic, the termination of an outside HOV lane, and the merging transit traffic into the mainline. SR 520 speeds would drop below 30 mph during the full 4.5-hour peak period.

Insert Figure

10 2030 PM Peak Period Traffic Operations – Safety and Preservation Alternative

Capacity constraints on SR 520 mainline and ramps would result in impacts to local streets and freeway system connections at the following locations:

- The westbound NE 40th Street/NE 50th Street CD would operate over capacity, causing congestion to back onto the NE 50th Street arterial system.

- Freeway queuing would back up to the arterial system at the West Lake Sammamish Parkway, NE 40th Street, and NE 50th Street interchanges.

- Queuing would begin at the ramp meter on the southbound Bellevue Way on-ramp and would extend onto the local arterial system.

The average westbound vehicle travel time on SR 520 from Avondale Road/SR 202 to I-5 during the 4.5-hour PM peak period is estimated to be 61 minutes, or an average speed of 13 mph. Travel times and speeds would be relatively slow between Avondale Road/SR 202 and I-405, averaging 40 minutes and 9 mph, respectively. The maximum westbound travel time on SR 520 from Avondale Road/SR 202 to I-5 would be 103 minutes, resulting in an average travel speed of 8 mph.

I-405 capacity constraints would limit the amount of traffic reaching SR 520 by nearly 210 vph during the peak period.

3.1.6.2 Eastbound SR 520 Findings

In 2030, the following vehicle volumes would be served across eastbound SR 520 during the 4.5-hour PM peak period (between 3:00 and 7:30 PM): 17,000 at 124th Avenue NE; 15,900 at Mid-Span; and 13,400 at Montlake Boulevard. During this 4.5-hour period, the following traffic volumes would not be served: 3,400 at 124th Avenue NE; 800 at Mid-Span; and 1,200 at Montlake Boulevard.

Capacity constraints (i.e., bottlenecks) would occur on SR 520 at the following locations:

- The 92nd Avenue NE on-ramp would cause speeds on SR 520 to be as low as 40 mph through the peak period.

- The I-405 corridor would be unable to serve the traffic demand approaching from the SR 520 ramps.

- The West Lake Sammamish Parkway off-ramp would operate at stop-and-go conditions for the majority of the peak period.

- The eastern corridor terminus at the Union Hill intersection and Redmond Way would operate at stop-and-go conditions for the majority of the peak period.

Capacity constraints on SR 520 mainline and ramps would result in impacts to local streets and freeway system connections at the following locations:

- Congestion beginning at the west terminus would spill back across SR 520 onto the local systems at the NE 51st Street, NE 40th Street, and 148th Avenue NE interchanges and onto the I-405 interchange ramps.

- Queuing would begin at the ramp meter on the southbound Bellevue Way on-ramp and would extend onto the local arterial system.

The average eastbound vehicle travel time on SR 520 from I-5 to Avondale Road/SR 202 during the 4.5-hour PM peak period is estimated to be 36 minutes, or an average speed of 22 mph. Travel times and speeds would be relatively slow between I-405 and Avondale Road, averaging 27 minutes and 14 mph, respectively. The maximum eastbound travel time on SR 520 from I-5 to Avondale Road/SR 202 would be 88 minutes, resulting in an average travel speed of 9 mph.

I-5 capacity constraints would limit the amount of traffic reaching SR 520 by approximately 300 vph during the peak period. I-405 capacity constraints would limit the amount of traffic reaching SR 520 by nearly 725 vph during the peak period.

3.1.7 Six-Lane Alternative AM Peak Period

Figure 11 shows the AM peak-period conditions on SR 520 that would result under the Six-Lane Alternative.

3.1.7.1 Westbound SR 520 Findings

In 2030, the following vehicle volumes would be served across westbound SR 520 during the 4.5-hour AM peak period (between 5:30 and 10:00 AM): 23,300 at 124th Avenue NE; 16,000 at Mid-Span; and 18,600 at Montlake Boulevard. During this 4.5-hour period, the following traffic volumes would not be served: 900 at 124th Avenue NE; 2,900 at Mid-Span; and 2,500 at Montlake Boulevard.

Capacity constraints (i.e., bottlenecks) would occur on SR 520 at the following locations:

- Queuing would begin at the entry point freeway where Avondale Road and SR 202 on-ramps merge, with congestion lasting over 3.5 hours. This congestion would extends onto the local street system.

Severe congestion occurring on I-5 would extend onto SR 520 across the lake. This stop-and-go operation would occur from 7:00 AM in the morning peak period and extend into the mid-day time period.

Capacity constraints on SR 520 mainline and ramps would result in impacts to local streets and freeway system connections at the following locations:

- The Avondale Road/SR 202 queue would limit the amount of traffic that could utilize the corridor. Without this bottleneck, additional downstream congestion would occur.

The average westbound vehicle travel time on SR 520 from Avondale Road/SR 202 to I-5 during the 4.5-hour AM peak period is estimated to be 32 minutes, or an average speed of 24 mph. Travel times and speeds would be stop-and-go between I-405 and I-5, averaging 21 minutes and 20 mph, respectively. The maximum westbound travel time on SR 520 from Avondale Road/SR 202 to I-5 would be 44 minutes, resulting in an average travel speed of 18 mph.

I-405 capacity constraints would limit the amount of traffic reaching SR 520 by nearly 705 vph during the peak period.

Insert Figure

11 2030 AM Peak Period Traffic Operations – Six-Lane Alternative

3.1.7.2 Eastbound SR 520 Findings

In 2030, the following vehicle volumes would be served across eastbound SR 520 during the 4.5-hour AM peak period (between 5:30 and 10:00 AM): 21,600 at 124th Avenue NE; 22,200 at Mid-Span; and 16,900 at Montlake Boulevard. During this 4.5-hour period, the following vehicle volumes would not be served: 11,700 at 124th Avenue NE; 1,800 at Mid-Span; and 1,500 at Montlake Boulevard.

Capacity constraints (i.e., bottlenecks) would occur on SR 520 at the following locations:

- Montlake Boulevard on-ramp area would be congested for more than 2 hours of the AM peak period.
- The drop lane to the southbound 148th Avenue NE off-ramp would result in congestion that would operate below 30 mph through 4 hours of the AM peak period.

Capacity constraints on SR 520 mainline and ramps would result in impacts to local streets and freeway system connections at the following locations:

- Queues would begin at the ramp meters on the Lake Washington Boulevard and 148th Avenue NE on-ramps and would extend onto the local arterials.
- The general freeway congestion would reduce the traffic volume that can be served from I-405.

The average eastbound vehicle travel time on SR 520 from I-5 to Avondale Road/SR 202 during the 4.5-hour AM peak period is estimated to be 32 minutes, or an average speed of 25 mph. Travel times and speeds on either side of I-405 are similar, averaging 15 to 17 minutes and 25 mph, respectively. The maximum eastbound travel time on SR 520 from I-5 to Avondale Road/SR 202 would be 46 minutes, resulting in a travel speed of 17 mph.

I-5 capacity constraints would limit the amount of traffic reaching SR 520 by nearly 620 vph during the AM peak period. I-405 capacity constraints would limit the amount of traffic reaching SR 520 by nearly 2,220 vph during the AM peak period.

3.1.8 Six-Lane Alternative PM Peak Period

Figure 12 shows the PM peak-period conditions on SR 520 that would result under the Six-Lane Alternative.

3.1.8.1 Westbound SR 520 Findings

In 2030, the following vehicle volumes would be served across westbound SR 520 during the 4.5-hour PM peak period (between 3:00 and 7:30 PM): 21,200 at 124th Avenue NE; 22,500 at Mid-Span; and 19,600 at Montlake Boulevard. During this 4.5-hour period, the following vehicle volumes would not be served: 2,700 at Mid-Span and 1,900 at Montlake Boulevard.

Insert Figure

12 2030 PM Peak Period Traffic Operations – Six-Lane Alternative

Capacity constraints (i.e., bottlenecks) would occur on SR 520 at the following locations:

- Queuing would begin east of the bridge at several interchanges. The general congestion that would occur through this area is caused by the activity at the I-405 and Bellevue Way on-ramps merge and 92nd Avenue NE off-ramp lane drop.

Capacity constraints on SR 520 mainline and ramps would result in impacts to local streets and freeway system connections at the following locations:

- Queuing would begin at the ramp meter on the Bellevue Way on-ramp and would extend onto the local arterial system.

The average westbound vehicle travel time on SR 520 from Avondale Road/SR 202 to I-5 during the 4.5-hour PM peak period is estimated to be 34 minutes, or an average speed of 23 mph. Travel times and speeds would be relatively slow between I-405 and I-5, averaging 25 minutes and 17 mph, respectively. The maximum westbound travel time on SR 520 from Avondale Road/SR 202 to I-5 would be 47 minutes, resulting in a travel speed of 17 mph.

I-405 capacity constraints would not limit the amount of traffic volume to SR 520.

3.1.8.2 Eastbound SR 520 Findings

In 2030, the following vehicle volumes would be served across eastbound SR 520 during the 4.5-hour PM peak period (between 3:00 and 7:30 PM): 23,300 at 124th Avenue NE; 17,900 at Mid-Span; and 14,800 at Montlake Boulevard. During this 4.5-hour period, the following vehicle volumes would not be served: 800 at Mid-Span and 1,200 at Montlake Boulevard.

Capacity constraints (i.e., bottlenecks) would occur on SR 520 at the following locations:

- The drop lane to the southbound 148th Avenue NE off-ramp results in congestion that would operate below 30 mph through 4 hours of the PM peak period. The queue would extend back to the I-405 interchange area.

- Congestion would occur at the West Lake Sammamish Parkway off-ramp due to the drop lane from the freeway mainline. The queuing would extend back to the 40th/51st CD on-ramp and would operate between 20 and 50 mph during the 4.5-hour peak period.

Capacity constraints on SR 520 mainline and ramps would result in impacts to local streets and freeway system connections at the following locations:

- Queues would begin at the ramp meters on the Bellevue Way, 148th Avenue NE, and NE 51st Street on-ramps and would extend onto the local arterials.

- The general freeway congestion would reduce the traffic volume that could be served from I-405.

The average eastbound vehicle travel time on SR 520 from I-5 to Avondale Road/SR 202 during the 4.5-hour PM peak period is estimated to be 21 minutes, or an average speed of 38 mph. Travel times and speeds would be relatively slow between I-405 and Avondale Road/SR 202,

averaging 13 minutes and 30 mph, respectively. The maximum eastbound travel time on SR 520 from I-5 to Avondale Road/SR 202 would be 23 minutes, resulting in an average travel speed of 34 mph.

I-5 capacity constraints would limit the amount of traffic reaching SR 520 by nearly 500 vph during the peak period. I-405 capacity constraints would limit the amount of traffic reaching SR 520 by nearly 100 vph during the peak period.

3.1.9 Eight-Lane Alternative AM Peak Period

Figure 13 shows the AM peak-period conditions on SR 520 that would result under the Eight-Lane Alternative.

3.1.9.1 Westbound SR 520 Findings

In 2030, the following vehicle volumes would be served across westbound SR 520 during the 4.5-hour AM peak period (between 5:30 and 10:00 AM): 22,700 at 124th Avenue NE; 16,600 at Mid-Span; and 16,800 at Montlake Boulevard. During this 4.5-hour period, the following vehicle volumes would not be served: 4,400 at 124th Avenue NE; 6,300 at Mid-Span; and 6,500 at Montlake Boulevard.

Capacity constraints (i.e., bottlenecks) would occur on SR 520 at the following locations:

- Queuing would begin at the entry point freeway where Avondale Road and SR 202 on-ramps merge, with congestion lasting over 3.5 hours. This congestion would extend onto the local street system.

- NE 51st Street off-ramp would have some localized congestion during the highest portion of the peak, with operating speeds around 40 to 50 mph.

- 148th Avenue NE would operate similar to NE 51st Street, with traffic slowing to 40 to 50 mph during the heavy part of the peak period.

- Severe congestion would occur on I-5 extending onto SR 520 across the lake, also congesting the I-405 interchange ramps. This stop-and-go operation would occur from 7:00 AM in the morning peak period and extend into the mid-day time period.

Capacity constraints on SR 520 mainline and ramps would result in impacts to local streets and freeway system connections at the following locations:

- The Avondale Road/SR 202 queue would limit the amount of traffic that could utilize the corridor. Without this bottleneck, additional downstream congestion would occur.

- Queuing would begin at the ramp meter on the Bellevue Way on-ramp and would extend onto the local arterial system.

- Congestion on SR 520 would cause a queue to form onto the Montlake Boulevard on-ramp.

Insert Figure

13 2030 AM Peak Period Traffic Operations – Eight-Lane Alternative

The average westbound vehicle travel time on SR 520 from Avondale Road/SR 202 to I-5 during the 4.5-hour AM peak period is estimated to be 69 minutes, or an average speed of 12 mph. Travel times and speeds would be stop-and-go between I-405 and I-5, averaging 60 minutes and 7 mph, respectively. The maximum westbound travel time on SR 520 from Avondale Road/SR 202 to I-5 would be 116 minutes, resulting in an average travel speed of 7 mph.

I-405 capacity constraints would limit the amount of traffic reaching SR 520 by nearly 580 vph during the peak period.

3.1.9.2 Eastbound SR 520 Findings

In 2030, the following vehicle volumes would be served across eastbound SR 520 during the 4.5-hour AM peak period (between 5:30 and 10:00 AM): 31,900 at 124th Avenue NE; 24,700 at Mid-Span; and 18,400 at Montlake Boulevard. During this 4.5-hour period, the following vehicle volumes would not be served: 2,300 at 124th Avenue NE; 1,300 at Mid-Span; and 1,600 at Montlake Boulevard.

Capacity constraints (i.e., bottlenecks) would occur on SR 520 at the following locations:

- Minor congestion would occur at the Lake Washington Boulevard on-ramp and at the NE 40th Street and NE 51st Street interchanges, with traffic speeds generally under 50 mph.

The average eastbound vehicle travel time on SR 520 from I-5 to Avondale Road/SR 202 during the 4.5-hour AM peak period is estimated to be 21 minutes, or an average speed of 38 mph. Travel times and speeds would be relatively slow between I-405 and Avondale Road/SR 202, averaging 13 minutes and 30 mph, respectively. The maximum eastbound travel time on SR 520 from I-5 to Avondale Road/SR 202 would be 23 minutes, resulting in an average travel speed of 34 mph.

I-5 capacity constraints would limit the amount of traffic reaching SR 520 by nearly 530 vph during the peak period. I-405 capacity constraints would limit the amount of traffic reaching SR 520 by nearly 625 vph during the peak period.

3.1.10 Eight-Lane Alternative PM Peak Period

Figure 14 shows the PM peak-period conditions on SR 520 that would result under the Eight-Lane Alternative.

3.1.10.1 Westbound SR 520 Findings

In 2030, the following vehicle volumes would be served across westbound SR 520 during the 4.5-hour PM peak period (between 3:00 and 7:30 PM): 27,300 at 124th Avenue NE; 28,200 at Mid-Span; and 20,900 at Montlake Boulevard. During this 4.5-hour period, the following vehicle volumes would not be served: 3,200 at 124th Avenue NE; 4,000 at Mid-Span; and 2,500 at Montlake Boulevard.

Capacity constraints (i.e., bottlenecks) would occur on SR 520 at the following locations:

- Montlake/Lake Washington Boulevard is congested through much of the peak period, with operational speeds below 30 mph for 3 hours.

Insert Figure

14 2030 PM Peak Period Traffic Operations – Eight-Lane Alternative

- Stop-and-go traffic would occur on I-5 and the interchange ramps with speeds below 30 mph during most of the 4.5-hour peak period, causing congestion to occur on SR 520 mainline.

Capacity constraints on SR 520 mainline and ramps would result in impacts to local streets and freeway system connections at the following locations:

- Queuing would begin at the ramp meter on the Bellevue Way on-ramp and would extend onto the local arterial system.

The average westbound vehicle travel time on SR 520 from Avondale Road/SR 202 to I-5 during the 4.5-hour PM peak period is estimated to be 24 minutes, or an average speed of 33 mph. Travel times and speeds would be relatively slow between I-405 and I-5, averaging 18 minutes and 23 mph, respectively. The maximum westbound travel time on SR 520 from Avondale Road/SR 202 to I-5 would be 29 minutes, resulting in an average travel speed of 27 mph.

I-405 capacity constraints would not limit the amount of traffic reaching SR 520.

3.1.10.2 Eastbound SR 520 Findings

In 2030, the following vehicle volumes would be served across eastbound SR 520 during the 4.5-hour PM peak period (between 3:00 and 7:30 PM): 24,300 at 124th Avenue NE; 22,800 at Mid-Span; and 16,700 at Montlake Boulevard. During this 4.5-hour period, the following vehicle volumes would not be served: 3,500 at 124th Avenue NE; 900 at Mid-Span; and 1,300 at Montlake Boulevard.

Capacity constraints (i.e., bottlenecks) would occur on SR 520 at the following locations:

- Congestion at the West Lake Sammamish Parkway off-ramp would extend back to the I-405 interchange during the 3-hour peak period. SR 520 would operate at stop-and-go conditions.

- Avondale Road/SR 202 would operate below 30 mph during 3.5 hours of the peak period.

Capacity constraints on SR 520 mainline and ramps would result in impacts to local streets and freeway system connections at the following locations:

- Queues would begin at the ramp meters on the Bellevue Way, 148th Avenue NE, and NE 51st Street on-ramps and would extend onto the local arterials and to the I-405 interchange ramps.

The average eastbound vehicle travel time on SR 520 from I-5 to Avondale Road/SR 202 during the 4.5-hour PM peak period is estimated to be 34 minutes, or an average speed of 23 mph. Travel times and speeds would be relatively slow between I-405 and Avondale Road/SR 202, averaging 26 minutes and 15 mph, respectively. The maximum eastbound travel time on SR 520 from I-5 to Avondale Road/SR 202 would be 61 minutes, resulting in an average travel speed of 13 mph.

I-5 capacity constraints would limit the amount of traffic reaching SR 520 by nearly 515 vph during the peak period. I-405 capacity constraints would limit the amount of traffic reaching SR 520 by nearly 360 vph during the peak period.

3.2 I-5

System summary charts similar to the ones presented for SR 520 have been developed for the I-5 corridor and can be found in **Appendix A**. I-5 operations were simulated between the NE 45th Street ramps to the south and the I-90 ramps to the north. The existing system summary charts illustrate that I-5 congestion occurs in the southbound direction near the Ship Canal Bridge and the I-90 off-ramp and in the northbound direction near the SR 520 off-ramp.

Comparison of the various alternatives shows that congestion becomes progressively worse for southbound I-5 as capacity is added to SR 520. Otherwise stated, the Safety and Preservation Alternative is worse than No-Action, the Six-Lane Alternative is worse than Safety and Preservation, and the Eight-Lane Alternative has the most congestion of all alternatives. This indicates that the increase in capacity on SR 520 adds southbound traffic to I-5, resulting in additional congestion on I-5. The addition of traffic is not a total peak period increase in trips, but rather an increase in traffic during a shorter period of time.

For example, the southbound I-5 Ship Canal Bridge limits the amount of southbound traffic that can be destined for areas south of Seattle, as does the westbound SR 520 lane configuration at Evergreen Point. These two locations allow enough traffic through that the I-5 corridor experiences congestion in the vicinity of the I-90 off-ramp that extends back to the SR 520 interchange. If we were to allow more traffic to cross the SR 520 bridge by adding lane capacity and improving the corridor design (added design capacity), then the amount of traffic entering the congested I-5 bottleneck would increase without any increased capacity on I-5.

The year 2030 analysis demonstrates that the proposed extensive TDM programs and the increases in transit service into downtown Seattle have had two impacts to travel in the Seattle area:

1. People destined for downtown Seattle have shifted from single-occupancy vehicles (SOVs) to HOVs or transit, thus reducing the number of vehicle trips into the City.

2. People remaining in SOVs and some HOVs are destined for areas north or south of downtown Seattle.

Growth is projected to continue on I-5 and SR 520, while the trips to downtown Seattle have decreased. This change in trip patterns results in additional traffic at the southbound I-5 bottleneck location near the I-90 ramps.

Another bottleneck for southbound I-5 traffic is located in the vicinity of the NE 45th Street on-ramp. This location is regularly congested during both the AM and PM peak periods. This means that the addition of any traffic demand during the peak periods would not be served until the off-peak periods. In essence, the southbound I-5 speeds would not be slower during the peak hour itself; rather they would stay slower for longer periods. Another effect of this bottleneck is the limiting effect it has on peak-hour traffic volumes destined for SR 520. The peak-hour traffic volume to SR 520 would not increase unless the proportionate share of traffic from the north increased to SR 520.

Northbound I-5 traffic south of the I-90 CD on-ramp is regularly congested as well. This location limits the amount of traffic that can ultimately reach the SR 520 corridor during the peak period. The effect of these congested locations is that the estimated demand from I-5 to SR 520 would not be served. **Table 1** summarizes the traffic that would not be served from I-5 to eastbound SR 520, due to capacity constraints, during both the total peak period and the peak hours.

Table 1. Unserved Traffic from I-5 to Eastbound SR 520

Alternative	Peak Period (4.5-Hour Total)		Hourly Average	
	AM	PM	AM	PM
No-Action	3,535	855	785	190
Safety and Preservation	2,000	1,350	445	300
Six-Lane	1,545	1,220	345	275
Eight-Lane	1,695	1,275	380	285

The highest volume of unserved trips would occur under the No-Action Alternative. This is in part due to the improvements proposed at the I-5 interchange under the Safety and Preservation and Six- and Eight-Lane Alternatives. The improvements include a new connection to the I-5 express lanes for HOV traffic in all alternatives and a realignment of off- and on-ramps to the right side in the Six-Lane and Eight-Lane Alternatives. These improvements, along with improvements on SR 520, would allow the Safety and Preservation and Six- and Eight-Lane Alternatives to serve more traffic from I-5 to SR 520. The Eight-Lane Alternative would have more unserved traffic from I-5 to SR 520 than the Six-Lane Alternative because the forecasted volume is higher, but the I-5 corridor could not serve any more trips to SR 520 with changes to I-5 as far south as the I-90 on-ramp to northbound I-5 and as far north as the NE 45th Street interchange area.

3.3 I-5 EXPRESS LANES

The I-5 express lanes serve as a key component to the Trans-Lake corridor alternatives. The Safety and Preservation, Six-Lane, and Eight-Lane Alternatives all include a direct HOV connection between SR 520 and the I-5 express lanes to the north and south. Analysis of the express lane operations assumes the lanes would operate southbound in the AM and northbound in the PM peak just as they do under current year 2002 operations. The express lanes merge/diverge from mainline I-5 just north of NE 103rd Street near Northgate Mall and just south of the Columbia Street area.

Express lane operations were simulated in the CORSIM program, and speed flow diagrams were developed to summarize the operations (see **Appendix B**). The speed flow charts represent the average speed across all lanes of traffic during the specified time period.

Existing conditions show that the average speed into the express lanes during the AM peak period is about 40 to 50 mph. Exiting the express lanes shows a queue that extends back to the SR 520 interchange area. This queue occurs in the center lane and is due to the heavy volume from the express lanes that is forced to join I-5 in a single lane. The PM peak operations are hampered at the SR 522 off-ramp to the north where traffic operating speeds dip below 20 mph for about 2 hours.

The No-Action Alternative illustrates that 30 years of traffic growth in the express lanes would result in worse conditions with the same general bottleneck locations. Congestion would occur in the AM peak period at the drop lane north of the SR 522 on-ramp. This congestion would border around 30 to 40 mph for about 30 minutes. The congestion that would occur in the PM peak period is extensive, originating at the locations near the SR 522 off-ramp where the far left lane converts to an HOV lane and the express lanes join with I-5 mainline. For 2 hours of the peak period, the queue would extend for the full length of the express lanes. The congestion at the north end would last for the entire PM peak period and would extend into the evening hours.

Under the Safety and Preservation Alternative, the southbound express lanes would have slightly worse operations than the No-Action Alternative due to the connection from westbound SR 520. The extent of the northbound congestion in the PM peak period in the express lanes would remain very similar to that shown in the No-Action Alternative.

Under the Six-Lane Alternative, congestion would increase southbound in the AM peak period approaching the bottleneck at the drop lane north of SR 522. Similar to the operations under the Safety and Preservation Alternative, the queue that forms as the express lanes approach I-5 mainline under existing conditions would be compounded by the traffic volume growth. The Six-Lane Alternative would alleviate some of the eastbound congestion on SR 520, thus making the express lane connection to SR 520 much more appealing and useful for the I-5 express lanes. The northbound congestion would still be considered severe through the peak period, but there would be some small relief periods due to a small shift in traffic to SR 520 and some of the SR 520 congestion that limits the amount of traffic would get to the express lanes north of SR 520.

Operations in the express lanes for the Eight-Lane Alternative would be very similar to the Six-Lane Alternative. A small amount of additional congestion would occur south of SR 520 during the AM peak due to the additional traffic demand that would use the express lanes during the AM peak period. The northbound operations would also be slightly more congested than under the No-Action Alternative due to the additional traffic demand.

Both the Six- and Eight-Lane Alternatives would be able to serve the trips from SR 520 to the I-5 express lanes during the AM peak period. A small benefit might be seen in travel time for the HOV traffic using the express lane connection versus using the I-5 mainline connections.

3.4 I-405

The I-405 corridor serves north/south traffic along the east side of Lake Washington and provides an essential connection between the communities that border the freeway. I-405 also serves as a major destination or source for SR 520 traffic. Because of the importance of interconnectivity between the two regional facilities, the I-405 corridor was evaluated between the NE 70th Street interchange and the NE 4th Street interchange. The I-405 speed charts are provided in **Appendix C**.

Similar to I-5, the I-405 corridor would be severely congested by the year 2030 under No-Action, and congestion is estimated to limit the amount of traffic that would reach the SR 520 corridor. The estimated unserved traffic volumes for the I-405 ramps to SR 520 are summarized in **Table 2**.

Table 2. Unserved Traffic from I-405 to SR 520

Alternative	Peak Period (4.5 Hour Total)				Peak Hour			
	Eastbound		Westbound		Eastbound		Westbound	
	AM	PM	AM	PM	AM	PM	AM	PM
No-Action	9,755	3,420	4,275	940	2,170	760	950	210
Safety and Preservation	9,885	3,260	4,390	935	2,200	725	975	210
Six-Lane	9,975	435	3,160	0	2,220	100	705	0
Eight-Lane	2,800	1,605	2,615	0	625	360	580	0

The Eight-Lane Alternative would serve more trips from I-405 primarily due to the easing of congestion on SR 520 and the new I-405 interchange layout. Adding a through lane on eastbound SR 520 to Avondale and eliminating the I-405 to 124th Avenue NE weaving area would allow more capacity on SR 520 to serve more of the peak-period demand. Also, the new I-405 interchange layout would eliminate the NE 8th Street to SR 520 weave, thereby allowing more traffic to be served through the peak period.

3.4.1 Transit and HOV Operations

Key findings previously documented overall operations for the general-purpose traffic. A component of some of the project alternatives is the completion of the HOV lane system on SR 520, including connections to I-5 and I-405.

HOV and transit lanes provide a critical function for moving people throughout the Puget Sound region, and the evaluation of those HOV lanes is an essential part of this discussion. The comparison is not clear in the data charts provided; however, it is clear that the SR 520 corridor would operate with several hours of congestion in the GP lanes for most of the alternatives. Part of the definition of the Six- and Eight-Lane Alternatives is the addition of a significant amount of transit service to the SR 520 corridor. This addition of service could only be possible if the HOV lanes were completed to provide the transit service a reliable corridor travel time. Because the transit vehicles alone would not fully utilize the lane capacity or the person-moving capacity of the HOV facility, it would also be designated as an HOV lane for vehicles with 3 or more people.

Constructing an HOV lane on the inside (instead of the outside as currently exists), striping a 4-foot separation between the HOV lane and the nearest GP lane, and providing median transit stops and direct connections to key destinations all would allow vehicles in the HOV lane to operate at optimal conditions. The improvements would ensure faster travel times along the corridor, thus allowing more buses and HOV vehicles to move more people during a shorter period of time.

Table 3 provides a breakdown per alternative for maximum travel time for the HOV general-purpose traffic during each of the peak periods.

Table 3. Transit/HOV Lane Travel Time (in minutes)

Alternative	Eastbound			Westbound		
	AM	PM	Average	AM	PM	Average
Existing	23	25	24	19	21	20
No-Action	32	38	36	17	48	33
Safety and Preservation	21	45	33	17	40	29
Six-Lane	10	14	12	15	13	14
Eight-Lane	14	15	15	16	15	16

The table represents the estimated westbound transit/HOV travel times on SR 520 between the Avondale/Redmond Way merge point to the I-5 interchange and eastbound travel times for the reverse trip. Travel times for each peak period and the average of the peak periods are presented in the table. HOV travel times would improve by up to 33 minutes in the westbound direction and 21 minutes in the eastbound direction under the Six- and Eight-Lane Alternatives as compared to the No-Action Alternative. A travel time savings of this level is considered significant when considering the number of people moved per transit and HOV vehicle. Assume a transit vehicle is carrying 60 people (nearly full)

and it saves 31 minutes in travel time. That equates to 1,860 minutes or 31 hours of person travel time savings. Further demonstration of the advantages is provided in the following paragraphs.

The following table presents examples of person travel time advantages with the provision of an HOV lane. This example focuses solely on the travel time benefits of the HOV lane. **Table 4** illustrates the person-hours of travel in the HOV lane operating at 60 percent of its total capacity during the peak hours. The purpose of this example is to illustrate how the estimated improvements in speed and travel time in the HOV lane would result in person-hours of travel time saved.

Table 4. Transit/HOV Lane Person Time (person hours)

Alternative	Eastbound			Westbound		
	AM	PM	Combined	AM	PM	Combined
Existing	1,650	1,700	3,350	1,350	1,700	3,050
No-Action	2,200	2,450	4,650	1,300	3,850	5,150
Safety and Preservation	1,550	2,050	3,600	1,300	2,900	4,200
Six-Lane	900	1,200	2,100	1,250	1,150	2,400
Eight-Lane	1,200	1,250	2,450	1,350	1,200	2,550

Assuming the same level of HOV and transit demand for all alternatives, the travel time benefits over 5,300 person-hours of travel time saved with the Six- and Eight-Lane Alternatives during the AM and PM peak hour.

4. COMBINED LOCAL AND FREEWAY SYSTEMS

Two traffic operations analysis paths ran concurrently for the SR 520 Trans-Lake Washington Project.

The first path evaluated the local street operations for each of alternatives and provided recommendations for intersection design based on the peak-hour traffic demand. The traffic demand correlated directly with the freeway on- and off-ramp forecasted peak-hour traffic volumes to ensure consistency between the traffic volume estimates and resulting operational behaviors. Recommendations from the local traffic operations analysis are available in the *Draft Year 2030 Local Traffic Operations* report.

The second path evaluated the freeway operations independent of the local street operations. The importance of this evaluation was to identify the magnitude of congestion along the freeways during the peak periods. This effort has been presented in the previous sections in this report. Each of the paths resulted in design recommendations that would be required to serve the full demand.

A third level of analysis was performed to ensure that the design modifications recommended in the two analysis paths would not result in adverse impacts from any recommended design modification downstream on local and freeway networks. This effort combined the local and freeway networks to determine if additional design modifications would be required to serve traffic at a level no worse than No-Action.

Because the definition of the alternatives assumes that I-5 and I-405 would retain their current number of lanes, there are limits to the amount of traffic that can ultimately reach the SR 520 corridor during any given period of time. There are also locations on the local street systems that operate at or over capacity that would not be able to service the forecasted traffic volume demands. Locations where traffic on either system would likely be blocked have been identified and are noted on **Figures 15** through **22**.

Without further analysis it is not possible to determine if modifications would be required along outlying arterials or freeway sections. An agreement with the local jurisdictions should be achieved to define what level of change they would accept to the local infrastructure to accommodate future traffic demands.

The combined freeway and local analysis was accomplished using peak-hour traffic volumes to identify the worst-case operations along the freeway and local street systems. The figures identify the problem areas and the peak time during which the problem would likely occur. If the problem occurs during both peaks (AM and PM), then that is identified on the figure.

The text following the figures discusses impacts to the transportation system and the possible solutions for the problem. Also included is a percentage of traffic that is not served at the interchange. The percentage of unserved traffic is sometimes due to the local arterial feeder system lacking the necessary capacity to serve traffic demand. At other times, the freeway system queues onto the local arterial, causing local congestion. Solutions are evaluated to determine how well congestion at each bottleneck would be eliminated.

Insert Figure

15 No-Action West Side

Insert Figure

16 No-Action East Side

Insert Figure

17 Safety and Preservation West Side

Insert Figure

18 Safety and Preservation East Side

Insert Figure

19 Six-Lane West Side

Insert Figure

20 Six-Lane East Side

Insert Figure

21 Eight-Lane West Side

Insert Figure

22 Eight-Lane East Side

4.1 COMPARISON OF ALTERNATIVES BY MEASURE OF EFFECTIVENESS

4.1.1 Traffic Volumes

Traffic volumes have been broken down for each alternative at various screenlines to provide a level of comparison. The peak-period traffic volumes served were summarized to account for congestion that extended throughout a peak period. Because the total volume demand is served during the peak period, as in the existing condition, this does not indicate that no congestion actually occurs. Instead, this simply shows that the traffic demand can be served during the peak period.

Table 5 compares the total amount of traffic that each alternative can serve during the AM and PM peak periods at six different screenline locations and for each direction of travel. This summary of data represents the assumed conditions modeled and does not include the final geometric configurations.

Table 5. Volume Served During AM and PM Peak Periods

AM Peak Period

	Volumes Serviced (vph)				
Description	EX	NB	SP	6-Ln	8-Ln
EB SR-520					
Between I-5 and Montlake	13,400	13,500	15,200	16,900	18,400
Bridge Mid-span	16,200	16,700	19,800	22,200	26,700
Between 108th and I-405	15,500	16,900	18,800	20,600	24,700
Between 124th and 148th	18,600	19,500	20,300	22,500	32,900
Between 148th and 40th/51st	14,300	16,400	17,000	21,600	31,900
Between WLS and Avondale	8,100	8,400	8,500	8,000	11,800
WB SR-520					
Between I-5 and Montlake	15,400	14,900	14,800	18,600	16,800
Bridge Mid-span	16,400	15,200	14,900	16,000	16,600
Between 108th and I-405	14,800	13,900	13,800	12,400	14,700
Between 124th and 148th	15,400	18,300	18,200	21,400	21,300
Between 148th and 40th/51st	15,400	21,400	21,100	23,300	22,700
Between WLS and Avondale	14,700	18,900	18,800	28,200	31,600

PM Peak Period

	Volumes Serviced (vph)				
Description	EX	NB	SP	6-Ln	8-Ln
EB SR-520					
Between I-5 and Montlake	14,100	13,700	13,400	14,800	16,700
Bridge Mid-span	15,500	16,200	15,900	17,900	22,800
Between 108th and I-405	15,500	16,600	16,500	17,100	22,200
Between 124th and 148th	16,300	17,700	17,700	23,300	25,700
Between 148th and 40th/51st	15,200	16,600	17,000	23,300	24,300
Between WLS and Avondale	13,400	14,800	14,800	26,800	29,700
WB SR-520					
Between I-5 and Montlake	15,500	14,700	15,600	19,600	20,900
Bridge Mid-span	17,800	18,500	20,200	22,500	28,200
Between 108th and I-405	14,600	12,200	15,100	17,000	21,800
Between 124th and 148th	16,500	11,100	16,700	28,300	29,500
Between 148th and 40th/51st	13,500	13,300	16,300	25,200	27,300
Between WLS and Avondale	7,600	7,800	8,900	10,500	13,000

Data in the tables consistently show that as capacity is added to the SR 520 corridor, more traffic can be served during the peak periods. The exception is during the AM period in the westbound direction between I-5 and Montlake Boulevard, where the volume served under the Eight-Lane Alternative would be less than under the Six-Lane Alternative. This would occur because the demand associated with the Eight-Lane Alternative would create a substantial impact to I-5—the freeway system would come to a halt through the peak period, limiting the total traffic served.

The Six-Lane Alternative would be congested during the same peak period; however, the total demand through the period would decrease enough to allow the system to recover and serve more trips. This does not suggest that there would be no impact to I-5 operations. In all cases, the I-5 speeds would decrease and congestion would extend further into the peak periods.

Another valuable comparison between the alternatives is the distribution of traffic volume. As lane capacity is added to the corridor, the volumes would increase to the east of I-405. The westbound No-Action Alternative appears to be contrary to this and would serve less traffic than existing conditions. That is due to the heavy congestion that would occur through the peak period and limit the amount of traffic that could be served.

4.1.2 Travel Speed

A comparison of the alternative's estimated travel speeds shows that the No-Action Alternative would have the slowest operating speeds. The Safety and Preservation Alternative would improve speeds along the SR 520 corridor by adding the full standard lane and shoulder widths, as well as improving the ramp designs to meet current design standards.

The speed charts show that under the No-Action and Safety and Preservation Alternatives, AM peak period speeds in the westbound direction would slow near the I-405 interchange (rather than near 76th Avenue NE as shown in existing conditions). This is the result of an anticipated travel pattern shift; a higher percentage of traffic traveling from the east side would be destined to I-405. The Six- and Eight-Lane Alternatives would add capacity to SR 520, making it more desirable for travel to the west, thus drawing more traffic across the bridge. Travel speeds for the Six- and Eight-Lane Alternatives would be higher than under the No-Action Alternative because of the added capacity and improvements to the interchange designs.

4.1.3 Travel Time

Travel times are dependent on speeds and distances traveled. Because the SR 520 corridor is basically divided in half at the I-405 interchange, two calculations were made for the travel time data. The first calculation estimated the travel time between the Redmond/SR 202 and I-405 interchanges. The second calculation represented the travel time between the I-5 and I-405 interchanges. **Table 6** provides comparisons of travel times for these two segments of SR 520.

During the AM peak period, travel times are lower compared to PM peak period for westbound traffic due to the shift in travel patterns to I-405 rather than across Lake Washington. During the PM peak, travel times are predicted to be higher for westbound traffic in the No-Action and Safety and Preservation Alternatives. This is the eastbound AM work trip traffic returning home combined with the higher PM peak non-essential trips to the west.

During the PM peak, eastbound traffic is delayed at the end of the corridor by congestion that emanates from the Avondale/202 interchange and the West Lake Sammamish interchange. Both locations of congestion would be caused by the inability of the local intersection network to serve the traffic demand. Some additional changes to design are possible to serve the traffic into the local system; however, those changes have not been implemented in design or discussed and agreed to for feasibility with the local jurisdictions.

Table 6. Alternative Travel Times for Two Sections of SR 520

AM Peak Travel Times

Direction	Freeway Segment	No-Action		Safety & Preservation		Six-Lane		Eight-Lane	
		Peak Period	Peak Hour	Peak Period	Peak Hour	Peak Period	Peak Hour	Peak Period	Peak Hour
Westbound	Avondale to I-405	9.8 min	13.3 min	10.3 min	14.1 min	11.8 min	11.3 min	8.6 min	10.3 min
	I-405 to I-5	8.7 min	8.7 min	7.9 min	7.7 min	20.6 min	32.2 min	60.2 min	105.7 min
	Total	18.5 min	22.0 min	18.2 min	21.8 min	32.4 min	43.5 min	68.8 min	116.0 min
Eastbound	I-5 to I-405	19.2 min	26.2 min	16.8 min	20.7 min	17.1 min	30.5 min	8.3 min	8.4 min
	I-405 to Avondale	6.5 min	6.5 min	6.5 min	6.4 min	14.7 min	15.6 min	6.5 min	7.0 min
	Total	25.7 min	32.7 min	23.3 min	27.1 min	31.8 min	46.1 min	14.8 min	15.4 min

PM Peak Travel Times

Direction	Freeway Segment	No-Action		Safety & Preservation		Six-Lane		Eight-Lane	
		Peak Period	Peak Hour	Peak Period	Peak Hour	Peak Period	Peak Hour	Peak Period	Peak Hour
Westbound	Avondale to I-405	74.2 min	117.1 min	39.8 min	82.9 min	9.4 min	17.2 min	5.8 min	5.8 min
	I-405 to I-5	36.2 min	35.7 min	21.1 min	20.5 min	24.9 min	29.6 min	18.2 min	23.5 min
	Total	110.4 min	152.8 min	60.9 min	103.4 min	34.0 min	46.8 min	24.0 min	29.3 min
Eastbound	I-5 to I-405	11.1 min	17.2 min	9.2 min	20.2 min	8.2 min	8.1 min	8.4 min	9.5 min
	I-405 to Avondale	34.2 min	69.4 min	26.7 min	67.6 min	12.5 min	15.2 min	25.6 min	51.8 min
	Total	45.3 min	86.6 min	35.9 min	87.8 min	20.7 min	23.3 min	34.0 min	61.3 min

4.1.4 Vehicular Queues

Vehicular queuing along the freeway system is directly tied to travel speeds. Also, it has been concluded from this analysis that enough of the traffic demand can access the freeway system from the local arterials to cause significant queues on the freeway for each of the alternatives. There are also queues identified on the local system that would need to be addressed in order to reach a traffic operations level no worse than the No-Action Alternative. Key locations where local queuing occurs and limits the amount of traffic that can reach SR 520 are as follows:

- Montlake Boulevard northbound south of Lake Washington Boulevard
- Bellevue Way northbound and southbound

5. CONCLUSIONS

Year 2030 travel forecasting and traffic operations analyses were conducted for freeway, local, and combined systems.

5.1 TRAFFIC VOLUME AND FLOW PATTERNS

Traffic volume and flow patterns were described in the *Year 2030 Travel Forecasting Working Paper* and are summarized again to provide clarity to the Conclusion section.

5.1.1 SR-520

Under the No-Action Alternative, the traffic demand on SR 520 is expected to grow with a similar rate to historic data, 0.6 percent per year. The traffic pattern would shift from regional trips from I-5 across the lake and local ramp-to-ramp trips on the east side (as seen under Existing Conditions) to traffic destined to and from I-405. This is due to congestion occurring at the west termini of the freeway at I-5 as seen today. There is a perceived benefit under year 2030 conditions to access I-405 to and from SR 520.

The traffic volume under the Safety and Preservation Alternative would have the same growth and flow pattern as the No-Action Alternative.

Under the Six-Lane Alternative, the traffic demand on SR 520 is expected to increase at a rate of 1 percent per year. The traffic pattern on SR 520 would remain as regional trips from I-5 across the lake (as seen under Existing conditions). This is due to the increased capacity across the SR 520 span.

Under the Eight-Lane Alternative, the traffic demand on SR 520 is expected to increase at a rate of 1.7 percent per year. The traffic pattern on SR 520 would appear similar to Six-Lane Alternative traffic distribution.

5.1.2 I-5

Growth on I-5 is projected to be about 1 percent per year through the year 2030. The growth on I-5 is projected to be similar for all alternatives. The additional traffic on I-5 associated with the growth would bypass downtown Seattle as regional trips through the City. Even the new trips to I-5 from SR 520 would not terminate to downtown Seattle.

5.1.3 I-5 Express Lanes

Growth on the I-5 express lanes is projected to be about 0.2 (AM peak) and 1.1 (PM peak) percent per year through the year 2030. The growth on I-5 is projected to be similar for all alternatives.

5.1.4 I-405

The traffic volume on I-405 would grow under the No-Action and Safety and Preservation Alternatives but would decrease under the Six- and Eight-Lane Alternatives because traffic on SR 520 shifts from I-405 to cross the span of SR 520.

5.2 SR-520 INTERNAL SYSTEM PERFORMANCE

This section summarizes internal (local arterial and SR 520 mainline) performance. The following discussions identify locations that would not be able to reasonably serve the traffic associated with the 2030 alternatives as a result of the freeway analysis (freeway system independent of local bottlenecks) and the combined analysis (freeway and local system).

5.2.1 No-Action and Safety and Preservation Alternatives

Under the No-Action and Safety and Preservation Alternatives, the following local arterials could not reasonably serve traffic destined to or from the freeway due to arterial congestion: Montlake Boulevard, Bellevue Way, 148th Avenue NE, NE 40th Street, West Lake Sammamish Parkway, Redmond Way, and Avondale Way.

Congestion would also occur on the freeway mainline due to deficiencies at the following locations:

- Bridge approach in the eastbound direction.
- Bridge (84th Avenue NE) approach in the westbound direction.
- Mainline drop lane near Redmond Way interchange in the westbound direction.
- 148th Avenue NE westbound on-ramp merge.

5.2.2 Six-Lane Alternative

Under the Six-Lane Alternative, the following local arterials could not reasonably serve traffic destined to or from the freeway due to arterial congestion: Montlake Boulevard, Lake Washington Boulevard, Bellevue Way, 148th Avenue NE, NE 40th Street, West Lake Sammamish Parkway, Redmond Way, Avondale Way.

Congestion would also occur on the freeway mainline due to deficiencies at the following locations:

- In the eastbound direction, approaching the Lake Washington Boulevard on-ramp merge.
- At the drop lane to southbound 148th Avenue NE off-ramp from eastbound SR 520.
- In the westbound direction, approaching the Redmond Way on-ramp merge and approaching the 84th Avenue NE on-ramp merge.

5.2.3 Eight-Lane Alternative

Under the Eight-Lane Alternative, the following local arterials could not reasonably serve traffic destined to or from the freeway due to arterial congestion: Montlake Boulevard, Lake Washington Boulevard, Bellevue Way, 148th Avenue NE, NE 40th Street, NE 51st Street, West Lake Sammamish Parkway, Redmond Way, and Avondale Way.

Congestion would also occur on the freeway mainline due to deficiencies at the following locations:

- At the drop lane to southbound 148th Avenue NE off-ramp from eastbound SR 520.
- In the westbound direction, approaching the Redmond Way on-ramp merge.

5.3 SR 520 REGIONAL SYSTEM PERFORMANCE

The SR 520 corridor serves as a regional route between I-5, I-405, and SR 202 (Redmond Way). Because each corridor is interdependent of the others, this section describes these dependencies.

5.3.1 I-5/SR 520 System Performance

In the southbound direction of I-5, the freeway mainline would have no additional capacity available at the Convention Center in the year 2030 for all alternatives during the peak periods. Any additional traffic accessing mainline I-5 would directly result in additional congestion. This congestion would queue onto westbound SR 520. HOV traffic from the Safety and Preservation Alternative and Six- and Eight-Lane Alternatives would have the option to bypass the I-5 mainline congestion via the HOV express lane connection.

For all 2030 alternatives, I-5 north of the Ship Canal Bridge and south of the I-90 CD on-ramp would be constrained in the peak hour.

Specific to the No-Action Alternative, congestion on eastbound SR 520 would impact I-5 operations.

5.3.2 I-5 Express Lanes/SR 520 System Performance

In the southbound direction, the express lanes would have no additional capacity available at the terminus in the year 2030 for all alternatives during the AM peak period. Any additional traffic accessing the express lanes destined to I-5 mainline would directly result in additional congestion, although the HOV traffic would have the option of bypassing the majority of the queue through the HOV lane that would terminate as the 5th Avenue off-ramp. At the location where the HOV lane exits the express lanes, HOV traffic would maneuver into the single through-lane to I-5 southbound (travel pattern as viewed in existing conditions).

In the northbound direction, the express lanes south of the SR 522 off-ramp (the beginning of the HOV lane designation) would be constrained in the peak hour. The HOV traffic associated with the new express lane/SR 520 interchange connection would be able to access the HOV lanes north of SR 522 and bypass any remaining congestion south of the express lane terminus.

5.3.3 I-405/SR 520 System Performance

Specific to the Six-Lane Alternative, congestion on eastbound SR 520 at the 148th Avenue NE interchange would queue across SR 520 onto I-405. Congestion would begin at 148th Avenue NE due to the drop lane to southbound 148th Avenue NE off-ramp from eastbound SR 520.

6. NEXT STEPS

The next steps for the SR 520 design team include an update to the present designs to include the modifications identified in **Table 7** in this report. These changes could result in modifications to structures, local impacts, right-of-way requirements, or even mainline alignments. Final impacts will not be assessed until the design team works through the adjustments.

In the face of inevitable system congestion, the Trans-Lake team will perform a more detailed evaluation into the percentage of traffic that would traverse the corridor as HOV traffic. The SR 520 corridor is predicted to experience high levels of congestion by the year 2030. Whether congestion occurs at the 76th Avenue NE area or at the I-5 interchange makes little difference when evaluating the corridor travel times. Because of this expected congestion, it appears that more than 14 percent of the Six-Lane Alternative's vehicle traffic would be HOV traffic. Further investigation should determine if the corridor congestion might induce a higher level of mode shift to HOV and transit.

Traffic operations analysis for the Trans-Lake Washington project followed a significant design effort and was used to validate the design assumptions. Results of this analysis have identified several locations where the design may not serve the traffic demand at a level any better than the No-Action Alternative. Based on the information available to date, this report has identified changes to design that would improve traffic operations at various locations. Because the next stage of the Trans-Lake Project is the documentation of the Draft EIS, traffic operations will be validated with the new design modifications.

The Trans-Lake Washington project team will meet with the various local jurisdictions to determine what level of changes to the local arterial system would be acceptable to provide traffic operations at a level no worse than No-Action conditions. Or, the discussions could identify a level of operations that the local jurisdiction would be willing to accept if worse than No-Action.

INSERT EXCEL SPREADSHEET

Table 7. Changes to Design

APPENDIX A

I-5 Speed Flow Charts

APPENDIX B

I-5 Express Lanes Speed Flow Charts

APPENDIX C

I-405 Speed Flow Charts